(19) JAPANESE PATENT OFFICE

PATENT ABSTRACTS OF JAPAN

(11) Publication number: 2001237212 A

(43) Date of publication of application: 31.08.01

(51) Int. Cl H01L 21/304
G21K 5/04
H01L 21/306
H05H 1/24

(21) Application number: 2000043777

(22) Date of filing: 22.02.00

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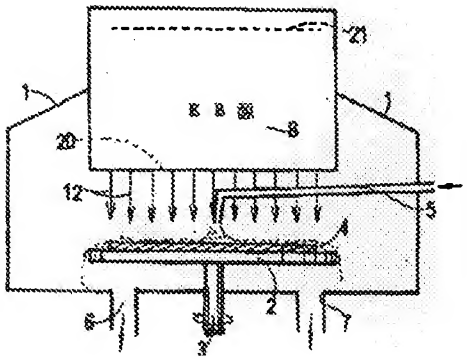
(54) METHOD AND DEVICE FOR ELECTRON BEAM TREATMENT

(57) Abstract:

PROBLEM TO BE SOLVED: To perform the ashing, cleaning, and flattening which are performed in a semiconductor wafer process by means of an electron beam irradiation device and, at the same time, to simplify the irradiation device through integration.

SOLUTION: A substrate placed on a rotary device set up in the air is treated by producing ozone or a hydrogen plasma, oxygen plasma, or halogen plasma by irradiating the substrate with an electron beam while the substrate is rotated in a state where a liquid chemical is supplied to the substrate.



DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the device and method of having applied the electron beam irradiation device to the resist removal device, the semiconductor substrate washing station, the glass substrate washing station for liquid crystals, the semiconductor substrate flattening device, etc. It says [that an electron beam irradiation device constitutes the introduction substrate cleaning device, or ** which constitutes a resist removal (ashing) device with an electron beam irradiation device constitutes a substrate flattening device with an electron beam irradiation device], Or the device which was made to perform these three functions with one electron beam irradiation device in common is provided. Therefore, speaking of a device, this invention is, [0002]1. Four inventions of washing, ashing, and a flattening device using the substrate flattening device 4. electron beam irradiation device using the substrate cleaning device 3. electron beam irradiation device using the resist removal (ashing) device 2. electron beam irradiation device using an electron beam irradiation device will be included. Although the same may be said of a method, since it is overlapping, it does not enumerate about a method.
[0003]
[Description of the Prior Art]It is necessary to consider the conventional technology from two directions. It is the conventional technology about completely different art of an electron beam irradiation device and a semiconductor process. Although it is an electron beam irradiation device first, in a vacuum, this generates a thermal electron, and accelerates and scans from a filament, is not scanned, but takes out an electron beam into the atmosphere through the window foil of a window of source container, and applies it to a processed material. A wire covering is strengthened according to polymers bridge construction, or various processings of hardening of a plastic sheet, coat hardening, etc. are performed. The space surrounded with the shield of metal with a thick processed material is sent to an exit from an entrance by a carrying conveyer. When electron beam energy is strong, powerful X-rays occur especially. Since it is harmful radiation, a device is made by shielding structure so that X-rays may not come outside. When oxygen is contained in atmosphere, an electron beam and X-rays generate ozone. Since ozone is harmful, flueing is important. It is necessary to take care that ozone does not leak to work environment. Since ozone is not preferred, atmosphere may be made into nitrogen gas or may be made into rare gas, such as Ar. A processed material is a dry material solid. A device which makes electron beam irradiation a wet sample does not yet exist. The above is the

present condition of an electron beam irradiation device. In the manufacturing process of a semiconductor device, ashing, substrate washing, and flattening processing are important processes, respectively. The art of a photolithography is used when producing a device according to a wafer process on a Si wafer. The parts of a wafer, a metal membrane, semiconductor membrane, a dielectric film, etc. are covered with resist (mask), the remaining disclosure portion is etched or a semiconductor, a dielectric, and metal are selectively grown up into the remaining disclosure portion. After carrying out such processing, it is necessary to remove resist.

[0004]Since resist is an organic matter, it is burned, and it is removed. It is ashing. Since a part of resist remains a little also after ashing, a substrate face is washed. In the case of a Si substrate, washing also has the purpose of removing the natural oxidation film of the surface made automatically. If a wafer process is piled up, the surface of a wafer will come to be tinged with unevenness, and the accuracy of a photolithography will also worsen. Then, it is necessary to make the surface flat. This is flattening processing. Such conventional technologies are described.

[0005]1. Ashing (incineration processing)

Two methods are known. One puts a substrate on an RF plasma device and a microwave plasma device, it introduces oxygen gas, generates oxygen plasma by RF power or microwave, by oxygen plasma, oxidizes and removes resist as carbon dioxide and water (CO_2+H_2O). Since resist is an organic matter, it burns by oxygen plasma. Since CO_2 of output and H_2O are gas, they are eliminated easily. There are some which heated the substrate with the heater. substrate heating -- resist -- incineration -- processing is promoted.

[0006]Another is a UV lamp (ultraviolet ray lamp) and a method of using ozone. A substrate (Si, glass) is put on the reaction chamber provided with the UV lamp, and it irradiates with a substrate with a UV lamp, introducing oxygen gas. Oxygen generates ozone with a UV lamp. Ozone is oxidized with the resist which is an organic matter, and resist is changed into carbon dioxide and water. It may process with ozone water and hydrogen water still more nearly eventually.

[0007]2. Washing board washing means washing of a semiconductor wafer (substrate), washing of the glass substrate for liquid crystals, etc. It may be said that a surface oxide film is removed in the case of a Si substrate. There is also the purpose of removing a resist residue more nearly thoroughly. The Si wafer of two or more sheets is put into a carrier, in the case of a Si wafer, it attaches to the flush tank containing hydrogen peroxide solution and an ammonia solution (H_2O_2+NH_4OH+H_2O), and it washes it. A surface oxide film, dirt, etc. are removed. Also in the glass substrate for liquid crystals, it soaks in the same penetrant remover, and it removes surface dirt. It may be said that a substrate is furthermore processed in HCl+H_2O_2 solution. The dirt of a substrate face and the residue of resist can be eliminated by a chemical reaction.

[0008]3. Flattening flattening is making flat the substrate with which unevenness produced the wafer process in piles. This is also an important process. The substrate was conventionally attached to the surface plate and it was grinding with the grinding stone which rotates while supplying the abrasive liquid containing chemicals and an abrasive grain. It is called CMP (ChemicalMechanical Polishing). Although an abrasive grain carries out physical polish, there is an operation which triggers a chemical reaction and deletes the

surface with medicine. Since it deletes with the grinding stone which is using together polish by mechanical friction, and the chemical reaction by chemicals, the surface of a wafer becomes flat.

[0009]

[Problem(s) to be Solved by the Invention]1. A substrate is made to soak and react to the tank of medicine, such as mixed liquor of hydrogen peroxide solution, ozone water, and hydrogen water, in washing of a [problem of washing] semiconductor substrate, and the glass substrate for liquid crystals. As for such medicine, concentration decreases with processing time progress. Since concentration is changed in time, maintenance of a high-concentration drug solution is difficult. There is a problem also in the stability of the medicine concentration in the place which processes. A method which medicine concentration always fixes is desired.

[0010]2. In the case of resist removal, such as a [problem of ashing] semiconductor substrate, and a glass substrate for liquid crystals, the device which generates oxygen plasma is used. The chemical reaction which generates an oxygen radical and oxygen ion, hits against resist, and generates diacid-ized oxygen etc. with this device is promoted, and resist removal is performed.

[0011]Not only resist but activity oxygen radical and oxygen ion also hit a substrates face and a device surface. A damage is given to the device currently produced by the semiconductor substrate which is a processed material, and the glass substrate by the collision to the substrate of an oxygen radical or oxygen ion. A device which does not give a damage other than a resist residue is desirable.

[0012]When resist forms compounds other than an organic matter system substance during processing of a previous process, it cannot remove only by oxidation treatment. Therefore, the non-organic matter needed to remain as after-processing residue, and another device needed to perform residue processing.

[0013]3. [problem of flattening] In the case of flattening of a semiconductor substrate and the glass substrate for liquid crystals, it is grinding with the emery wheel stone, supplying an abrasive grain and a drug solution. Since it is mechanical polish, damage may be done to the device currently formed in the substrate. The abrasive grain used for polish dries and this soils a wafer and a device. The raising dust by an abrasive grain pollutes a device, and the device yield is reduced. A flattening method for which it does not depend on the mechanical polish by an abrasive grain is desired.

[0014]

[Means for Solving the Problem]In atmospheric pressure, supplying a fluid to the surface of a semiconductor substrate and a glass substrate, irradiate with an electron beam and with an electron beam Ozone or oxygen plasma, Hydrogen plasma or halogen plasma is generated and a fluid, ozone or oxygen, hydrogen, and halogen plasma perform substrate washing, ashing, and flattening processing. This is the feature of this invention. Since a point of electron beam irradiation is common, it can perform three processings with one electron beam irradiation device. A kind of fluid changes with the purposes and processed materials of processing. There is also a case of a drug solution which may be pure water and has reactivity. Since ozone occurs by electron beam irradiation in any case, a reaction is promoted by this. Or it may be said that an electron beam changes hydrogen, oxygen, and halogen into a hydrogen radical, an oxygen radical, and halogen radicals, and makes a desired reaction cause.

[0015]

[Embodiment of the Invention]A common electron beam irradiation device is used for this invention to

ashing, washing, and three processes of flattening of differing. Drawing 1 explains the outline of a device. The spin cup 1 of a cylindrical shape is the container which accommodated the disc-like turntable 2. The turntable 2 is supported with the axis of rotation 3. The axis of rotation 3 rotates with suitable revolving speed. The substrates 4 which are processed materials, such as a Si wafer and a glass substrate, are **** (ed) on the turntable 2. The chemical nozzle 5 is prolonged to the center of the turntable 2. Or it is in the edge part of a turntable and has come to be able to carry out the regurgitation of the drug solution in the center of a turntable. The chemical nozzle 5 can introduce various drug solutions to the center of the turntable 2 by a processing purpose. There are the exhaust port 6 and the exhaust port 7 in the pars basilaris ossis occipitalis of the spin cup 1. The small electron beam irradiation device 8 (source of EB) is formed in the upper part of the spin cup 1.

[0016]The source 8 of EB consists of the electron beam generating filament 21, a filament power source, an accelerating electrode, an acceleration power source, a window of source container, etc. A filament generates a thermal electron in a vacuum, this is accelerated, and an electron beam comes out outside (atmospheric pressure) through the window foil 20 of a window of source container. The electron beam irradiation device was produced as a large-sized and independent device, and was used until now. If an electron beam hits a processed material, X-rays will come out. If atmosphere is air, ozone will occur for an electron beam or X-rays. Since ozone is harmful, it is made into a nitrogen atmosphere and argon atmosphere. Forced exhaust of the ozone is carried out and it is excluded. Here, it shall be a small electron beam irradiation device, and the upper part of the spin cup should be accompanied. the small electron beam irradiation device itself [such] -- it is new. A common electron beam irradiation device generates a thick powerful electron beam with the number MeV - the accelerating energy of 100keV.

[0017]There are a scanning-type and two types of a non-scanning-type. In a scanning case, the electron beam of the large voltage of 500keV - 5MeV is generated, and it scans it right and left. In a non-scanning-type, the electron beam of a large diameter is generated with about [100keV-500keV] low energy. It is the window foil 20 of a window of source container which divides a vacuum and the atmosphere. As for the window foil 20, Ti foil, Al foil, etc. are used. In the case of this invention, accelerating energy is lower, and it uses the electron beam of about [10keV-100keV] very low energy. Therefore, it becomes an acceleration power source and an accelerating electrode may also be small, and small as a whole. A small thing which is attached to the upper part of a spin cup can be used.

[0018]A drug solution, solution, water, etc. are supplied from the chemical nozzle 5, and atmosphere has cases, such as air, oxygen gas, hydrogen gas, and halogen gas. In any case, the plasma of ozone or oxygen, hydrogen, and halogen occurs with an electron beam. This invention is not so, although ozone was obstructive, and it was harmful and being exhausted through the eliminating unit in the old electron beam irradiation device. The plasma of ozone or oxygen, hydrogen, and halogen by which it is generated on the contrary is used effectively. The plasma of ozone or oxygen, hydrogen, and halogen is generated in plenty one after another. It becomes a remarkable advantage of this invention to use this effectively.

[0019]

[Example][-- 1. -- ashing device] by electron beam irradiation -- ashing is incinerating and removing the resist which finished the role of the mask. Generating oxygen plasma with a plasma generator conventionally, or generating ozone with a UV lamp required. This invention uses an electron beam irradiation device. Drawing

2 is an enlarged drawing of the surface of the substrate 4 in the spin cup 1 when this invention is applied to ashing. The resist 9 is attached to the upper surface of the substrate 4 in some places. This is the portion which became a mask by the etching process of the previous process. By etching, the portion in which resist does not exist is scooped out deeply and serves as the crevice (hole) 10. Since the spin of the substrate is carried out, a fluid spreads uniformly on the surface of the substrate 4. A resist crowning is thinly covered with a drug solution. The drug solution 11 is filled in the crevice 10 of the substrate. Let atmosphere be oxygen or air. Let the drug solution 11 be pure water or resist removing liquid.

[0020]The electron beam 12 occurs in the source 8 of EB (electron beam irradiation device) established above the spin cup 1, and the window foil 20 is penetrated. Since the electron beam 12 comes out of the filament 21 with a large area, its beam area is large. The electron beam of uniform density is irradiated by the whole substrate 4. An electron beam triggers an organic-matters-decomposition reaction in resist. Although it is a direct effect, there is a more effective operation. Oxygen becomes ozone with an electron beam. Although eliminated as this being more injurious than beneficial, in this invention, the flourishing organic matter oxidation by ozone is used.

[0021]Although it is the same operation as ozone water etc., in the case of this invention, since ozone is made from an electron beam, concentration does not become thin. Always new ozone can be supplied. A drug solution (pure water, resist removing liquid) fills a crevice, and since an electron beam is slowed down and absorbed with a drug solution, it cannot arrive even at the bottom of the crevice 10 inside a wafer depending on electronic accelerating energy or liquid thickness. A crevice is protected from the operation by an electron beam. Since such selectivity is brought about, a drug solution is sprinkled to a wafer surface and the spin of the wafer (substrate) is carried out. Liquid thickness can be set as a proper thing at spin number of rotations.

[0022]Resist oxidizes in an operation of ozone, with an electron beam, it promotes oxidation reaction, also has the chemical action of resist removing liquid, and exfoliates from a substrate face. The resist 9 is eliminated from the exhaust port 7 with a drug solution. Controlled atmosphere ozone is discharged from the exhaust port 6. An ozone level can be uniformly held in time by income-and-outgo balance.

[0023][-- 2. -- washing station] by electron beam irradiation -- drawing 3 is a substrate sectional view of the electron-beam-irradiation washing station of this invention. There is the crevice (hole) 10 by etching in the wafer (substrate) 4. The drug solution 13 is sprayed on the wafer surface. Since the wafer is rotating by the spinner, an oil level holds uniform thickness. With a subject, a fluid (drug solution) uses pure water, hydrogen water, an etching reagent, release liquid, etc. properly. Here, the resist residue 14 and the foreign matter 15 (particle) are made an issue of. Since a drug solution enters the crevice 10 deeply, it can slow down and absorb an electron beam. An electron beam declines with a drug solution and pure water, and it does not act on a crevice. Since the crevice is important at some devices, being protected from an electron beam collision is convenient.

[0024]Since the resist residue 14 has come out to the surface, it receives the exposure of an electron beam strongly. An operation of ozone is also received. It oxidizes, and a resist residue decomposes and is eliminated (CO_2). When a foreign matter is a metal powder, atmosphere is made into hydrogen or hydrogen water is mixed to the drug solution. A hydrogen radical will be formed if an electron beam hits hydrogen.

This contains an excitation neutral water matter molecule, an excitation neutral hydrogen atom, excitation hydrogen content child ion, etc. Since it is not hydrogen of a ground state, reactivity is strong. The foreign metallic particle which had adhered to the surface by the hydrogen radical is removed. In the case of an inorganic substance and metal, it dissolves by the oxidation by ozone, and the reducing action by a hydrogen radical, and comes to be discharged with a fluid.

[0025]When saying that he would like to take the natural oxidation film of a Si substrate, the method of exciting hydrogen with an electron beam and making it into a hydrogen radical is effective. Thus, an electron beam irradiation device can be used also for substrate washing. Since an electron beam is applied from on pure water or drugs, a crevice is protected. Since it has got wet, the charge up does not happen. Since conductivity is good, current flows into a substrate, and is discharged and the charge up does not occur. Therefore, a semiconductor device is not necessarily destroyed by the charge up. The role of drugs may be called charge-up prevention.

[0026][-- 3. -- flattening device] by electron beam irradiation -- drawing 4 is a substrate sectional view of the electron-beam-irradiation flattening device of this invention. There is the crevice (hole) 10 by etching in the wafer (substrate) 4. A certain projected quality 16 of a structure is shown in a wafer surface. The quality 16 of a structure has various cases, such as SiO_2, SiN, AlN, Al wiring, and a copper electrode. The drug solution 17 is sprayed on the center of a wafer. In this case, the drug solution 17 is a chemical etching reagent. Since the wafer is rotating by the spinner, an oil level holds uniform thickness. Even if it calls it a chemical etching reagent, it uses properly by an object. The drug solution 17 with the operation which corrodes the quality 16 of a structure is chosen. Since the drug solution 17 enters the crevice 10 deeply, it can slow down and absorb an electron beam. An electron beam declines with a drug solution and it does not act on a crevice. Since the crevice is important at some devices, being protected from an electron beam collision is convenient. The point is the same as an old example.

[0027]The quality 16 of a structure has projected and is directly exposed to an electron beam. An operation of an electron beam is received strongly. The corrosive action by drugs is also received. Ozone is produced when water is included. Ozone is generated also from atmosphere. The quality 16 of a structure is removed by the chemical action of ozone and a drug solution. If a high portion is removed, it will be exposed of a portion high next and will come to receive an electron beam operation. It is removed from a high portion. Therefore, a concavo-convex **** substrate face becomes flat. Since hydrogen water is suitable rather than ozone when many metal and oxides are included, the hydrogen water which makes atmosphere hydrogen or contains hydrogen in high concentration is included in a drug solution. A hydrogen radical will be generated if an electron beam hits hydrogen. A hydrogen radical is rich in a reducing action. An oxide and a foreign metallic particle can be removed by this. Since the chemical etching solution can maintain a flat face by spin rotation, a substrates face becomes flat soon. Since physical thrust or frictional force do not work, a damage is not given to a device. This is the outstanding flattening art.

[0028]In the case of flattening of concavo-convex **** polycrystalline silicon, a fluorine system drug solution, for example, fluoric acid solution, is used. Electron beam irradiation is performed supplying this on the surface of polycrystalline silicon. Silicon does not melt into fluoric acid solution. However, SiO_2 which is an oxide of silicon melts into fluoric acid. Ozone generates by electron beam irradiation. The surface of

polycrystal Si oxidizes by electron beam irradiation and ozone. The portion which oxidized serves as SiO_2. Since SiO_2 melts into fluoric acid, it dissolves in an instant. flowing, since it will become a fluid, if it dissolves -- last ** Thus, Si changes from the upper part to SiO_2 by electron beam irradiation and ozonate, and dissolution removal of the SiO_2 is carried out at fluoric acid. Since the fluid by which spin was carried out holds the same level surface, it is removed from the high portion of polycrystal Si. Therefore, flattening is carried out. Since electron beam irradiation makes ozone and such a reaction also oxidizes Si by this and electron-beam-irradiation operation, a reaction progresses and it dies. Only by there being oxygen, oxidation is slow and cannot carry out flattening.

[0029]

[Effect of the Invention]In the case of flattening, it is not necessary to use an abrasive grain. The problem of the raising dust by a dry abrasive grain is lost. Contamination by raising dust is escaped. Since mechanical polish which put the pressure is not carried out, there are few problems of the damage of a device. There is no room for machinery distortion to enter. It is the strong point which was excellent also in this.

[0030]When carrying out ashing of the resist, since the field of the crevice of a wafer is protected by the drug solution etc., an electron beam does not pass along it and ozone does not generate it in a crevice. It is easy to contact ozone, and the portion projected on the surfaces, such as resist, reacts by ozone, it becomes gas and is eliminated. In contrast, the substrates face of a crevice is protected by the solution and the crevice of a wafer surface does not receive a damage. Since a crevice is the portion by which the device was produced, being protected from an electron beam is convenient.

[0031]Since a substrate is always filled with water or a drug solution, even if it irradiates with an electron beam, the charge up does not start. device damage the charge up starts, when an electron beam is applied to an insulator substrate (glass substrate) or a semi insulator board, since it is high tension, a device may be destroyed, but in the case of this invention, the substrate is always damp, and the charge up does not happen, but according to high tension -- ********** . Water and a drug solution have a lot of roles and meanings which are called crevice protection, charge-up prevention, the base of ozone, and base of a hydrogen radical.

[0032]What was explained above has described the thing of the simple substance as an ashing device, a washing station, and a flattening device. However, if it thinks, since it will be the same structure, in a substrate process, three processes of ashing, washing, and flattening can be continuously managed using the same device. It is also possible to reduce the number of the devices itself.

[0033]However, it becomes conditions that that it can use for such a use has electron beam energy still lower than an old device. The grade which acts only on a substrate face may be sufficient because contamination is taken or resist is removed. Don't enter by the inside of a substrate rather. It is better not to act on a substrate face and a device surface. Fluids, such as pure water and a drug solution, protect a device surface. Therefore, it is also necessary to generate the electron beam of low energy without an example, such as 10keV - 50keV, or 5keV.

[Translation done.]